DOCUMENT RESUME

ED 394 439 HE 029 133

AUTHOR Civian, Janet; Schley, Sara
TITLE Pathways for Women in the Sciences II: Retention in Math and Science at the College Level.
PUB DATE Apr 96
NOTE 23p.; Paper presented at the Annual Meeting of the American Educational Research Association (New York, NY, April 8-12, 1996).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Persistence; Case Studies; College Environment; *College Mathematics; College Preparation; *College Science; Educational Background; Females; Grades (Scholastic); Higher Education; High Schools; Longitudinal Studies; Mathematics Education; Parent Background; Predictor Variables; *School Holding Power; Science Education; Scores; *Student Attitudes; Student Attrition; *Womens Education
IDENTIFIERS *Wellesley College MA

ABSTRACT

A study followed 445 Wellesley College (Massachusetts) women students matriculating in 1991 through their college years to isolate factors associated with persistence in math and science. Data were gathered through three surveys (at orientation, at the end of the sophomore year, and before graduation) and in focus groups over the 4 years of the study. Four possible pathways in science were examined: "never", "leaver", "joiner", and "always." Slightly over half fell into the first group; "leavers" comprised 22 percent; "joiners" were 4 percent; and "always" consisted of 18 percent. Characteristics of each group are discussed, with special focus on students leaving science and mathematics. It was found that members of this group tended to have lower high school grades in math and science, lower entrance examination math scores, and lower college grades in science and math. "Leavers" also reported lower levels of interest in science and lower mathematical ability, and were less likely to have a parent with an advanced degree than students who stayed in math and science. "Leavers" said they left science because they found other fields more interesting and because laboratory work required too much time. Findings suggested that the culture of science at Wellesley does not appear to discourage students. (MSE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 394 439

Pathways for Women in the Sciences II: Retention in Math and Science at the College Level

Janet Civian
Sara Schley
Wellesley College

Mailing address:
Janet Civian
Office of Institutional Research
Wellesley College
106 Central Street
Wellesley, MA 02181-8259

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
Janet T. Civian
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Paper presented at the annual meeting of the American Educational Research Association, April 1996, New York City.

HE029133

BEST COPY AVAILABLE

Introduction

This paper draws upon data collected by the Pathways Project for Women in the Sciences,[1] a study located at the Center for Research on Women at Wellesley College. This longitudinal study follows the Wellesley College Class of 1995 from orientation until graduation to understand factors associated with attraction to the fields of mathematics, computer science and science,[2] and retention in those fields. A descriptive report was issued early in the study (Rayman & Brett, 1993) and a final report is forthcoming.[3] In the present analysis, we are concerned with retention among the group of students who arrive at Wellesley with an interest in majoring in science. Among the women who report at orientation that they plan to major in math or science, over half defect to other fields by graduation.

As a selective college, Wellesley attracts many women with high scientific and mathematical ability. As a women's college, Wellesley's culture is thought to support students in pursuing non-traditional careers. With a math and science faculty that is 58% female, an able student body, and a supportive culture, the stage seems set for retaining women in science. This paper draws upon survey, focus group and administrative data to explore the differences between those who persist in math and science and those who do not.

---

[1] This study is funded by the Alfred P. Sloan Foundation.

[2] For the purposes of this study, psychology is not considered a science major although psychobiology is included.

[3] In addition to the undergraduate study, the Pathways reports describe the results of two alumnae studies, one tracking Wellesley classes 1983-1991 and the other tracking classes 1968-82. The alumnae studies are concerned with retention in science beyond college as well as issues related to balancing work and family in scientific careers.

Background

Retention of women in math and science continues to be of interest to researchers and scientists concerned with equity. Nationally, women continue to lag behind men in the number of math and science courses they take in high school, in the election of math and science majors in college, and in the choice of scientific careers (Davis et al., 1996) . Several quantitative and qualitative studies have been conducted to understand these phenomena as they play out at the college level (see especially Seymour & Hewitt, 1994; Astin & Astin, 1991). The number of years of math and science courses taken in high school appears positively associated with choosing a science or math major (Ware and Lee, 1988; Ethington and Wolfle, 1988), as do self-ratings in ability in mathematics (Ethington, 1988). In addition, Astin and Sax (1996) report that high school grades and SAT Math scores are positively associated with choosing a science major, but placing a high priority on family and having a high orientation toward helping others are negatively associated with choosing a science major. In their study of undergraduates, Ware, Steckler and Lee (1985) identified parental education among other predictors that have a positive influence on the choice of a science major. Seymour and Hewitt (1994) add that high intrinsic interest in the subject and an orientation positioned away from the materialistic end of the reward scale and toward the altruistic end are associated with choosing a quantitative major.

The Sample

The Pathways Project follows the 583 women who enter Wellesley in Fall 1991 throughout their college years to isolate factors associated with retention in math and science. These women are surveyed during orientation to ascertain anticipated major, experiences with

science in high school, self-esteem, sex-role attitudes, perceptions of ability, valued characteristics of a future career, and background characteristics. Students are surveyed again during their first year if they take a course in science, math or computer science; this second survey asks about experiences in the course, sense of preparation, perceptions of science and mathematics, and ratings of self-esteem and ability. Students are surveyed again at the end of their sophomore year when they declare their major(s).[4] This third survey includes several items from previous surveys as well as additional items about student employment, interaction with faculty, the decision process of choosing a major, and research experience in science. Finally, students are given an extensive survey before graduation concerning their experiences at Wellesley and their future career plans. The response rate for each of these surveys is listed in Table 1. The final analytic sample includes 445 students, which represents 76% of the original entering cohort.[5] In addition to surveys, dozens of students participate in focus groups over the four years of the study, probing topics such as choosing a major, experiences in introductory science courses, and experiences as a physical science major versus a life science major.

The Four Pathways ....

We examine four possible pathways in science: "Never," "Leaver," "Joiner," "Always" (see Figure 1). The "Nevers" are students who at orientation plan on majoring in a nonscience area and graduate with a nonscience major. Slightly more than half the sample falls into this category (n=249, 56%). A large portion of students arrive at Wellesley thinking that they will major in

---

[4] 28% of this cohort elect two majors

[5] These 445 students completed surveys at the two primary time points -- orientation and graduation. We have surveys for most of these students at the sophomore time point as well, and data from administrative sources for all students in the sample at all time points.

science but in the end they decide not to; these are the "Leavers" (n=99, 22%). Sixteen students (4%) are classified as "Joiners"; these students do not intend to major in science when they arrive at Wellesley, but change their minds once here. Finally, the "Always" group is composed of 81 women (18%) who enter with the intention to major in science and who do in fact graduate with a science major.

The Leavers and the Always. The Leavers are an especially interesting group because they come to Wellesley thinking that they might major in math or science, but something changes, and they decide not to choose a quantitative major. Most of these students decide on a nonscience major by spring of sophomore year (n=84). Fifteen students actually declare a math, science, or computer science major at the end of their sophomore year but drop it before graduation.

What distinguished the Leavers from the Always group? Table 2 compares these two groups along several of the dimensions identified by other research as predictors of retention in science. Compared to the Always group, the Leavers come to Wellesley with about the same amount of preparation (as measured by number of years of high school science and math) but with slightly lower SAT Math scores and slightly lower high school grades in math and science (note that while these differences are statistically significant, as a practical matter the differences are quite small). In terms of parental differences, Leavers are less likely than those who majored in math/science to have a parent with an advanced degree but just as likely to have a parent who is employed in a math or science field. In terms of background characteristics, then, these bivariate relationships would appear to support previous research that high school grades, SAT Math scores and parental education are associated with choosing a math/science major.

A sex-role measure was created from four items designed to determine if a student has traditional ideas about sex roles or non-traditional ones (Mason, Czajka & Arbor, 1976); the reliability measure (Cronbach's alpha) for this scale is .70. Research by Astin and Sax (1996) indicates that students with traditional sex-role attitudes are less likely to pursue science because they perceive it as incompatible with raising a family. In this sample, there is no difference in the sex-role measure for the Leavers as compared to those who choose a major in math or science. Seymour and Hewitt (1994) report that students who tend toward more materialistic career goals are less likely to major in math and science. In this sample, we find no differences between the Leavers and the Always group on either a scale measuring materialism (Cronbach's alpha = .78) or a scale measuring altruism (Cronbach's alpha=.73).

We ask all of our students in their final survey if Wellesley encourages women to pursue science. Among the group which arrives with an interest in science, at least four out of five students agree at the graduation time point that Wellesley encourages women to pursue science. This is true even among those who decide not to pursue science, as no differences are found between the Leavers and the Always group in their responses.

Several characteristics seem to present themselves as particularly important in comparing the students who thought they would major in science and did not, versus those who persisted in science. First, large differences exist in students' self-ratings of mathematical ability (both at the orientation time point and the sophomore time point); Leavers are much less likely than the Always group to rate themselves as above average or in the top 10% of mathematical ability. Interestingly, while confidence levels for both groups drop between fall of the first year and spring

of the second, the two groups diminish in confidence[6] at the same rate (a Mann-Whitney U test on the difference scores fails to find a distinction between the two groups). The importance of mathematical self-confidence in pursuing science is documented by Ethington (1988) and Ware, Steckler, and Leserman (1985) and appears to play a role for the women in this study.

When asked for their self-rating in interest in science (relative to the average person their age), we find a huge difference between the Leavers and the Always group: *students who persist in science are three times more likely than students who leave science to rate themselves in the top 10% of those interested in science.* Interestingly, while the two groups have very different assessments of their own mathematical abilities and intrinsic interest in science, they share an interest in premedical studies. A picture begins to emerge, then, where we see that both of these groups enter with the same amount of math and science coursework and an initial interest in premedical studies, but very different levels of intrinsic interest in science and mathematical ability. When we couple this with another predictor of interest -- math and science GPA at Wellesley -- the picture comes into clearer focus. The Leavers have a much lower performance in their Wellesley math and science courses than do those retained (GPA of 2.56 versus 3.30). Given the lower levels of interest reported by the women who left science, one can imagine that a few low grades in science would be enough to divert their interest to other fields of study. It is fascinating to see that many of these women are not completely diverted from science, however: *note that 20% of the leavers report at graduation that they completed premedical studies at Wellesley while majoring in a nonscience area.* Later in this paper we test by means of logistic

---

[6] It is hard to know if mathematical confidence actually diminishes or if the difference simply represents the change in the students' reference group from high school to Wellesley. Note that the question asks, "How would you rate yourself on each of the following traits as compared with the average person your age?"

regression the relative effects of several of these predictors in understanding retention in science and math.

Focus groups with Leavers give us personal stories about the experiences of these students. We hear from many students that they become disenchanted with science because of the time involved. According to one student, "I found that a lot of things I wanted to do on campus I couldn't do with a science major because it requires way too much time." One pre-med found that her attachment to pre-medical studies faded and she was lured to other fields. She states, "There are so many classes that I want to take here, and ... I didn't want to be in lab all the time. It wasn't that important to me." Other students decide a medical career seems too demanding. As one student says, "You give your life soul for it [medicine]... I am interested in it, yes, but not wedded to it."

A question on the sophomore survey sheds additional light on the reasons why the Leavers opt for a nonscience major. We ask students, "If you <u>are</u> <u>not</u> majoring in science or math, please tell us why" and invit them to circle the three most important reasons from a list of nine. Responses for the Leavers are displayed in Figure 2. By far the most frequently cited reason is that students develop an interest in other areas of study (84%). The second most often cited reason is that laboratories are too lengthy (45%). Between 20% and 30% of students say that they do not like math, that math/science courses are too difficult, or that they do not like science. Only 14% report that the grading is too difficult, 9% object to the amount of math involved, 5% report discouragement from teachers and 5% report discouragement from parents. Coupled with the profile we developed earlier, we see that this group of Leavers has lower interest in science, lower grades in science, and a concomitant development of interests in other areas. Where do

they go? For these 99 women who leave science, we see from Figure 3 that most of them -- about two-thirds -- defect to the social sciences. About a third select a humanities major and a quarter choose an interdisciplinary major outside of science.[7]

There is a special category of Leavers that deserves attention. Among the 99 Leavers are 15 women who initially plan to major in science, actually choose a science major at the end of their sophomore year, but then drop out of science before graduation. While this group is small, it is interesting because it speaks to the narrowing of the flow of women into the science pipeline. We find that seven of these women are not lost to science: four switch from a science/math major to a minor (one of whom graduates with pre-medical requirements met), two switch to cognitive science[8] (one of whom graduates with pre-medical requirements met), and one switches to a political science major but graduates with her pre-medical requirements met. The remaining eight women report that they simply became interested in other fields of study. One woman writes, "Anthro is a subject I find more intellectually intriguing" while another states, "I was more interested and passionate about economics." We wondered about other factors that might contribute to their decision to drop the science major after sophomore year, so we examined the same attributes used to compare the Leavers and the Always group to try and identify any differences between the early Leavers and the later Leavers. We found no differences save one: the math and science college GPA for the later Leavers is about a half-point higher than that of the early Leavers (2.92 versus 2.48, $p < .01$). The higher "success" rate of these students perhaps

---

[7] Note that percentages add to more than 100% due to students majoring in more than one area.

[8] Cognitive science is obviously an allied science field, but it is not considered within our strict definition of science for the purposes of this study.

contributes to their staying in math and science awhile longer, despite the fact that their profile in virtually every other way mirrors the rest of the Leaver group.

The Joiners. Only 16 students in this cohort are classified as having "joined" science. Six of these students select a nonscience major at sophomore year but then switch to a science major sometime before graduation. The remaining ten enter with the intention of majoring in the humanities or social sciences, but declare a science major at the end of sophomore year. Half of these women barely qualify as Joiners because they are on a pre-medical track throughout their college career. The remaining eight include four who select a geology major, two psychobiology, one biochemistry, and one computer science. Virtually all of these students enjoyed science and math in high school and report that they did well in those courses; they just expected to pursue other fields in college. The computer science major chose her field for practical reasons, and the geologists and psychobiologists seem to have stumbled on their fields and been drawn to them. The pre-medical students expected to pursue humanities or social sciences while completing their pre-medical studies, but ultimately decided to major in science.

Testing the effects

Looking at the bivariate relationships gives us a good picture of the Leavers, but does not isolate the most important factors contributing to the decision to major in a nonscience field. We elected to estimate several reduced logistic regression models to control background characteristics and isolate factors associated with retention of women who initially declare an interest in science. We refer to these as reduced models because they include only a subset of the factors discussed earlier due to the high degree of collinearity among them. While other

promising approaches to analyzing these data include structural equation modeling and discriminant analysis, we elected to begin our investigation with logistic regression. We plan to continue our investigation of these data with structural equation modeling to analyze the direct and indirect influences of background factors and college experiences that contribute to choosing a career in science.

In order to minimize collinearity, only the following predictors are included in a model predicting retention in science for women who express an initial interest in science: parental education, self-rating of interest in science (collected at orientation), science GPA at Wellesley, self-rating in mathematical ability (collected at sophomore year), an extrinsic reward measure (high levels indicate a desire for materialistic rewards), and sex-role attitude (high levels indicate a liberal orientation). Only three predictors are retained in the final model: parental education, science GPA at Wellesley, and self-rated interest in science (see Table 3). Mathematical ability, the extrinsic reward measure and the sex-role measure are dropped from the model due to nonsignificance. While parental education is retained in the model as a control variable, it only approaches statistical significance at .0793. Its effect is in the expected direction: the Always group is twice as likely as the Leaver group to have a parent with an advanced degree. The other two effects also follow the expected pattern: the Always group is seven times more likely to be represented in the higher science/math GPA levels than the Leavers, and the Always group is three times more likely than the Leavers to be represented in the higher rankings of self-ratings in interest in science.

SUMMARY

In bivariate relationships, several factors appear to be associated with leaving math and science for Wellesley students who express an initial interest in these fields. Leavers tend to have lower high school grades in math and science, lower SAT Math scores, and lower grades in math and science at Wellesley. Additionally, they report lower levels of interest in science and lower levels of mathematical ability. Finally, Leavers are less likely to have a parent with an advanced degree than the group that stays in math and science. In our final logistic regression model, lower self-reported interest in science and lower math and science GPA at Wellesley predict leaving science. Parental education also remains in the model but only approaches statistical significance.

Leavers tell us that they choose nonscience majors because they find other fields more interesting and because laboratories take up too much time. We also know that Leavers arrive at college less interested in math and science and that they are less "successful" (as measured by college grades) in their math and science classes than the students who persist. All these factors likely contribute to the complex decision-making web of choosing a major. Interestingly, 20% of the Leavers continue in their pre-medical studies despite defecting from the major, so at least one-fifth of these students are not lost from science forever. It also appears that it is not the culture of science at Wellesley that discourages the Leavers, as both groups -- the Leavers and the Always alike -- report that Wellesley encourages women to pursue science.

References

Astin, A. W. and Astin, H. S. (1993). *Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in Science.* Los Angeles: Higher Education Research Institute, UCLA Graduate School of Education.

Astin, H. S. & Sax, L. J. (1996). Developing Scientific Talent in Undergraduate Women. In C. Davis, et al. (Eds.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering* (pp. 96-121). San Francisco: Jossey-Bass

Civian, J. T. with P. M. Rayman & B. Brett. (forthcoming). *Pathways for Women in the Sciences: The Wellesley Report (Part II).* Wellesley, MA: Wellesley College Center for Research on Women.

Davis, C., Ginorio, A. B., Hollenshead, C. S., Lazarus, B. B., Rayman, P. M. and Associates. (1996). *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering.* San Francisco: Jossey-Bass.

Ethington, C. A. (1988). Differences Among Women Intending to Major in Quantitative Fields of Study. *The Journal of Educational Research, 81,* 354-359.

Ethington, C. A. and Wolfle, L. M. (1988). Women's Selection of Quantitative Undergraduate Fields of Study: Direct and Indirect Influences. *American Educational Research Journal, 25,* 157-175.

Mason, K. O., Czajka, and Arber, S. (1976) Change in U.S. Women's Sex-Role Attitudes. *American Sociological Review, 41.*

Rayman, P. M. & Brett, B. (1993). *Pathways for Women in the Sciences: The Wellesley Report (Part I).* Wellesley, MA: Wellesley College Center for Research on Women.

Seymour, E., and Hewitt, N. M. (1994). *Talking About Leaving: Factors Contributing to High Attrition Rates Among Science, Mathematics & Engineering Undergraduate Majors.* Final report to the Alfred P. Sloan Foundation. Boulder, CO: University of Colorado Bureau of Sociological Research.

Ware, N. C. and Lee, V. E. (1988). Sex Differences in Choice of College Science Majors. *American Educational Research Journal, 25,* 593-614.

Ware, N. C., Steckler, N. A. and Leserman, J. (1985). Undergraduate Women: Who Chooses a Science Major? *Journal of Higher Education, 56,* 73-85.

Table 1
Response rates for Class of 1995 Pathways surveys (n=583)

Survey	n	percent
Orientation	538	92%
Introductory science/math courses	422	72%
Sophomore year	420	72%
Senior year	445	76%

Table 2
Comparing "leavers" (thought they might major in science but did not) to the "always" group (thought they might major in science and did)

Measure	Leavers (n=99)	Always (n=81)	Test of statistical significance (1)
SAT Math	636	661	**
Number of years of high school science/math	8.7	9.2	n.s.
GPA in high school science/math courses (2)	89.9	92.4	***
GPA in college science/math courses (3)	2.56	3.30	***
Sex-role composite (4)	3.43	3.31	n.s.
Money/prestige important	2.23	2.12	n.s.
Helping others important	2.80	2.74	n.s.
Rates self in highest 10% in interest in science	15%	46%	***
Rates self above avg or in highest 10% in math ability at orientation	66%	82%	**
Rates self above avg or in highest 10% in math ability at sophomore year	49%	75%	***
Parental education higher than BA/BS	62%	78%	*
Parent in math/science	48%	59%	n.s.
Premed at orientation	62%	65%	n.s.
Premed at graduation	20%	47%	***
Wellesley encourages women to pursue science	80%	86%	n.s.

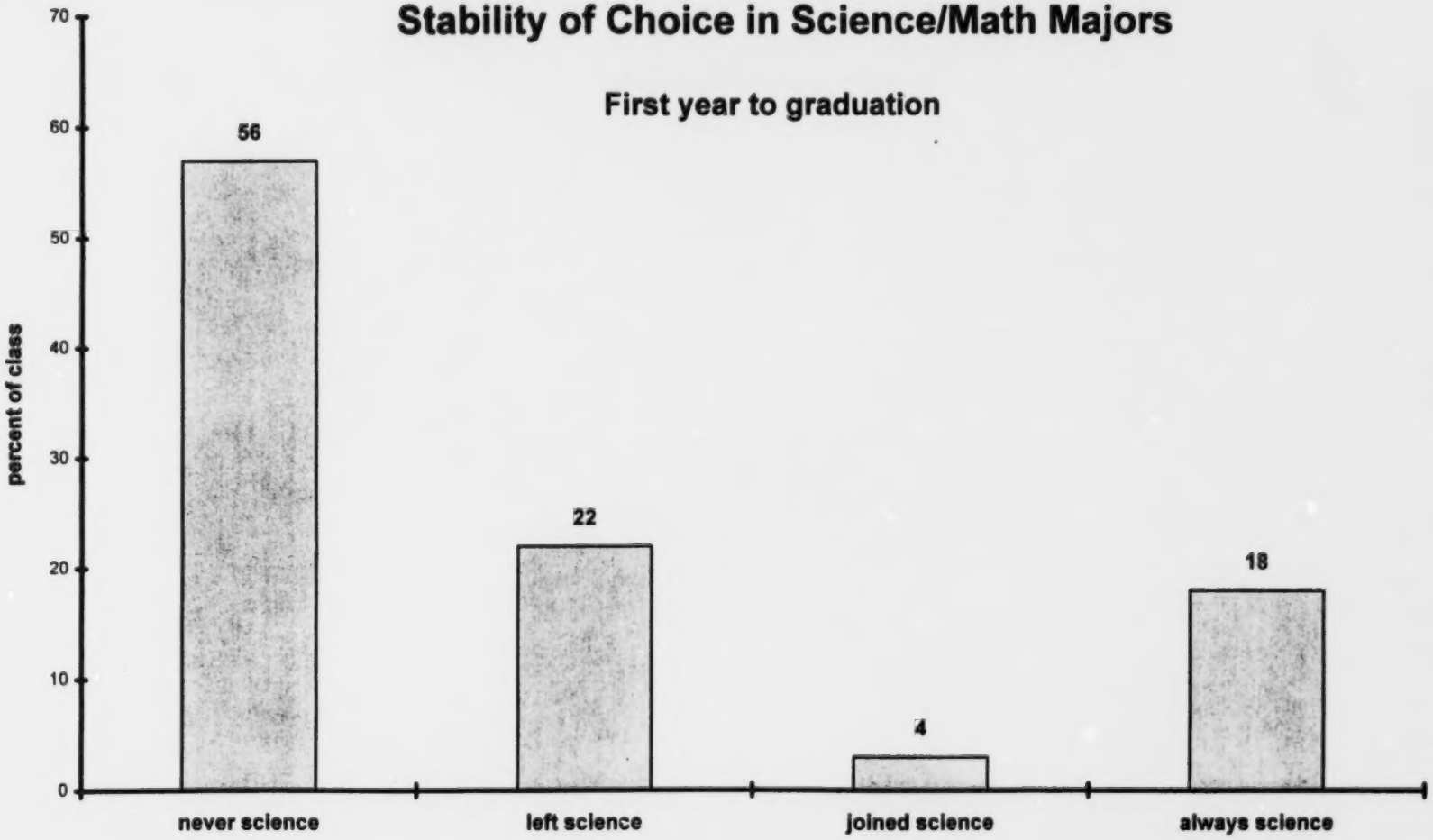
(1) T-tests were estimated for continuous variables, chi-square tests for categorical ones
(2) High school GPA calculated on a 100-point scale
(3) College GPA calculated on a 4-point scale
(4) Low values on the sex-role composite indicate traditional sex-role attitudes

n.s. = nonsignificant * $p < .05$ ** $p < .01$ *** $p < .001$

Table 3
Estimated logistic regression coefficients
predicting retention in science
for students who thought they would major in science

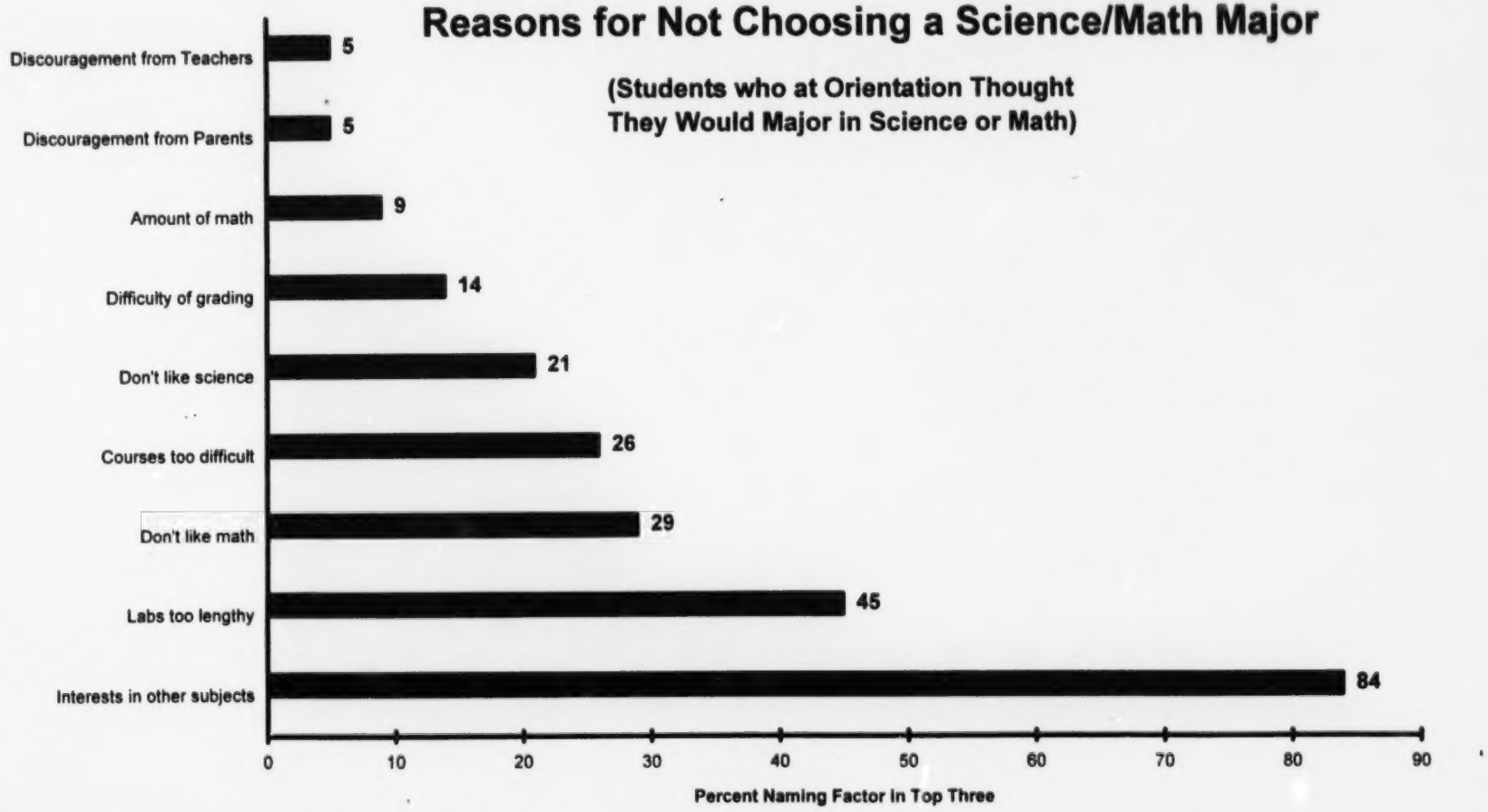
Variable		B	se
Parent education		0.790	0.450
Science GPA at Wellesley		1.927	0.387***
Interest in science		1.186	0.300***
Intercept	-12.270		
-2 log likelihood	151.653		

Figure 1



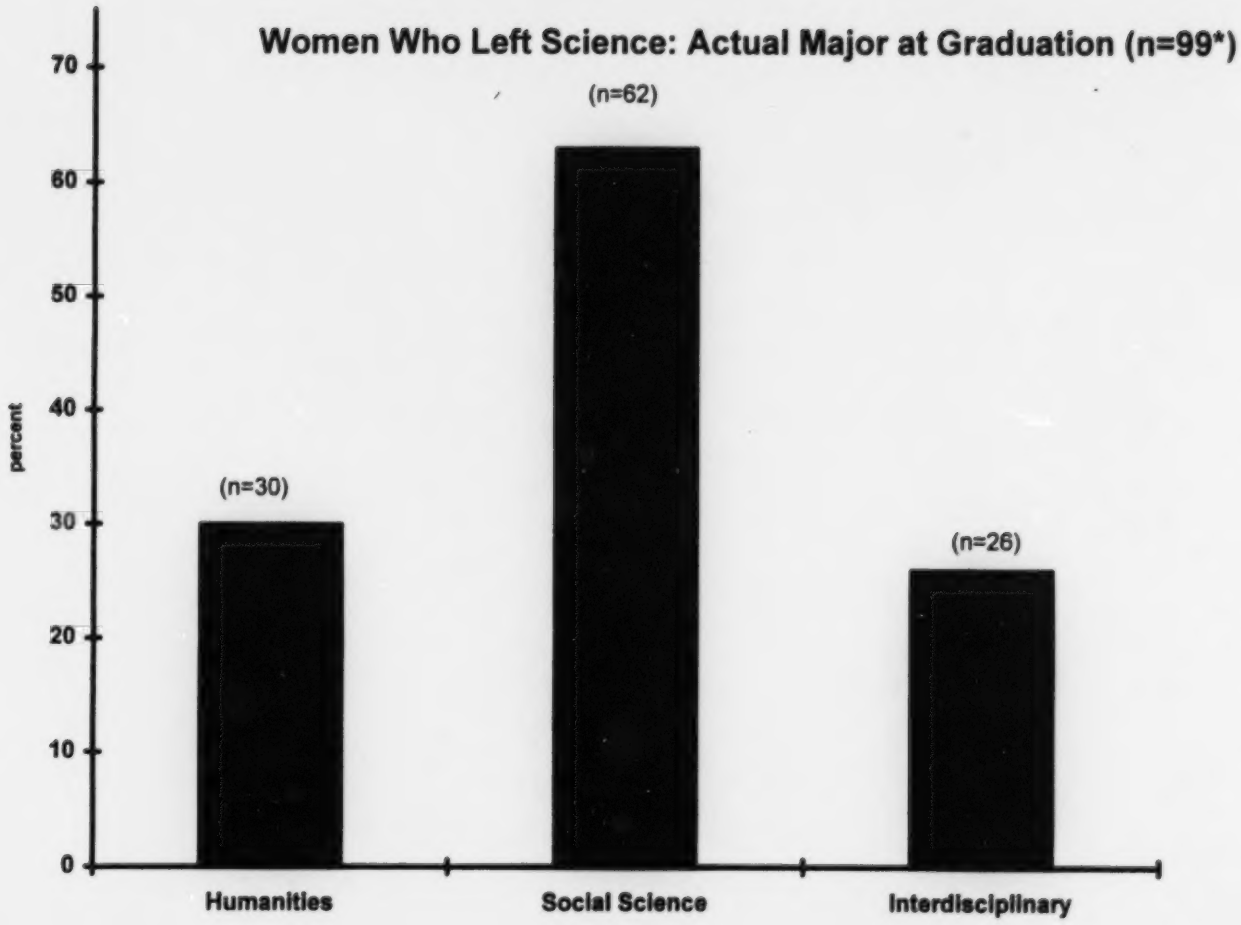
AERA1.xls

Figure 2



AERA2.xls

Figure 3



*n's in chart add to more than 99 due to presence of double majors